SMITHSONIAN CONTRIBUTIONS TO KNOWLEDGE.

ON

CERTAIN STORMS

IN

EUROPE AND AMERICA,

DECEMBER, 1836.

BY

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ON THE

AMERICAN STORM OF DECEMBER 20, 1836, AND THE EUROPEAN STORM OF DECEMBER 25, 1836.

About twenty years ago, I undertook to investigate the phenomena of a violent storm which swept over the United States about the 20th of December, 1836, and the result of my investigations was published in the *Transactions of the American Philosophical Society*, vol. vii. pp. 125–163. This storm extended from the Gulf of Mexico to an unknown distance on the north. The fluctuation of the barometer increased with the latitude, at least as far as Quebec, the most northern point from which observations could be obtained. The area covered by the observations included, therefore, only the southern half of the storm, and the phenomena of the northern half could only be supplied by conjecture. I, therefore, regarded the results of this investigation as unsatisfactory; but being unable to obtain observations from more northern stations, I published the information which I had obtained, and sought for a more hopeful subject of investigation in the case of some storm which was wholly embraced within the area of our observations. Such was the storm of February 4, 1842, with regard to which I fortunately obtained abundant materials for investigation. In conducting this investigation I adopted some peculiar methods, which, so far as I have been informed, had never been practised before. The phenomena of the storm, at intervals of twelve hours, were delineated on a series of maps of the United States, in such a manner that every important feature was made to appeal directly to the eye.

Those portions of the map corresponding to places where the sky was unclouded were colored blue; those portions where the sky was overcast, but without rain or snow, were colored brown; those portions of the country where rain was falling were colored yellow; and those portions where snow was falling were indicated by a green color. The direction of the wind was represented by arrows, and its force indicated by their length.

The observations of the barometer and thermometer were represented in the following manner: Having determined, as well as I was able, the mean height of the barometer at each station, I compared each observation with the mean. I then drew on the map a line connecting all those places where the barometer, at a given hour, stood at its mean height. This line was called the *line of mean pressure.* I then drew a line connecting all those places where the barometer, at the same hour, stood two-tenths of an inch *above* the mean; another line connecting all those places where the barometer stood four-tenths of an inch above the mean, etc. A line was also drawn connecting all those places where the barometer stood two-tenths of an inch *below* the mean; another line four-tenths of an inch below the mean, etc. These lines may be called *lines of equal barometric disturbance.*

In like manner a line was drawn connecting all those places where the thermometer stood at its mean height for the given hour and month; and this was called the *line of mean temperature.* Another line was drawn connecting all those places where the thermometer stood ten degrees *above* the mean; and other lines were drawn connecting those places where the thermometer was twenty degrees above the mean; ten degrees *below* the mean; twenty degrees below the mean, etc. These lines may be called *lines of equal thermometric disturbance.*

This mode of representing the observations of the barometer and thermometer appears to me the most suitable of any which has yet been proposed, to indicate the connection between the pressure and temperature of the air on the one hand, and the direction of the wind and the fall of rain on the other.

The results of the investigation of the storm of February 4, 1842, were entirely satisfactory to myself, and were published in the *Transactions of the American Philosophical Society*, vol. ix. pp. 161–184. Being convinced of the superior advantages of this new method of investigating the phenomena of storms, I immediately constructed upon the same principle a series of maps, representing the progress of the storm of December 20, 1836; and I perceived that certain features of this storm were thus brought out more clearly than I had been able before to exhibit them; but their publication has hitherto been delayed by the serious expense attending the preparation of a series of colored maps. As, however, my paper upon this storm has been commented upon by Messrs. Espy, Hare, and Redfield, and some conclusions have been drawn from it which appear to me unwarranted, I have thought it important that the maps should be published, with some accompanying remarks sufficient for their explanation.

Before issuing this reinvestigation of the storm of December 20, 1836, I have employed every means in my power for obtaining additional observations, and have met with some success. I have obtained copies of meteorological journals, including barometric observations, from the following stations, in addition to those employed in my first investigation:—

Station.	Latitude.	Longitude.	Observer.
Fort Snelling . . .	44° 53′	93° 12′	J. N. Nicollet.
New Orleans . . .	29 57	90 0	Prof. E. H. Barton.
Cincinnati	39 6	84 27	Prof. Joseph Ray.
Portsmouth, Ohio . .	38 42	82 54	Dr. G. L. B. Hempstead.
Steubenville, Ohio . .	40 25	80 40	Roswell Marsh.

About the 25th of December, 1836, a remarkable storm was experienced over nearly the entire continent of Europe, and some meteorologists supposed that this storm was the same as the American storm of December 20th. In order to prosecute this inquiry, I collected European meteorological journals for this period as far as they were within my reach. These stations were twelve in number, and a synopsis of the results was published in 1840, as a part of my first paper above referred to. This examination did not favor the supposition of any intimate connection between the American storm of December 20th and the European storm of December 25th; nevertheless, the observations were too few in number to indicate all the phenomena of the European storm. During a visit to Europe in 1856 and 1857, I improved the opportunity to collect additional observations for December, 1836, and succeeded in obtaining barometric observations from twenty-five additional stations, besides a few registers which were deficient in observations of the barometer. Having projected these observations upon a series of maps in the manner described with reference to the storm of February 4, 1842, I perceived that the phenomena of this storm were very remarkable, differing in some respects from any which I had previously seen investigated, and I then resolved to make a further effort to obtain materials for rendering the investigation in all respects complete. I accordingly addressed letters to twenty-five meteorologists in different countries of Europe, soliciting copies of their journals for the period in question. In answer to these letters I have received observations from twelve additional stations, so that now I have barometric observations from forty-seven stations, extending over nearly every country of Europe. I propose to present a summary of these observations, after first examining the American storm.

AMERICAN STORM OF DECEMBER 20, 1836.

Observations of the Barometer.

The following table presents a summary of the observations of the barometer at each of the American stations: column first shows the name of the station; columns second and third their latitude and longitude; and column fourth the mean height of the barometer at each station. The numbers in this column have been derived in the following manner: For all those stations where there has been made a series of observations extending over several years, the mean of this series, whenever it could be ascertained, has been inserted in column fourth. For the remaining stations the assumed mean height is that due to the supposed height of the station above the sea, corrected in some cases by comparison of the observations made simultaneously at neighboring stations where the mean height of the barometer was pretty well determined. The fluctuations of the barometer were required for 8 A. M. and 8 P. M. of each day; and whenever these hours did not correspond to the actual hours of observation at any station, the height for these hours was interpolated by a comparison of the preceding and subsequent observations. The numbers thus obtained were diminished by the mean height of the barometer for that station, and the remainders are inserted in columns five to twelve; which accordingly show how much the barometer was above or below its mean height for the dates given at the top of the table:—

STATIONS.	Latitude.	Longitude.	Mean height.	BAROMETRIC FLUCTUATIONS.							
				DECEMBER 19TH.		DECEMBER 20TH.		DECEMBER 21ST.		DECEMBER 22D.	
				8 A. M.	8 P. M.	8 A. M.	8 P. M.	8 A. M.	8 P. M.	8 A. M.	8 P. M.
			Inches.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.
Fort Snelling	44° 53′	93° 12′	29.00	.00	—.11	—.14	—.18	+.30	+.41	+.20	—.31
Natchez	31 34	91 24	29.80	+.15	—.01	—.21	+.12	+.48	+.53	+.44	+.24
New Orleans	29 57	90 00	30.09	+.26	+.16	—.01	+.04	+.42	+.50	+.51	+.32
Pensacola	30 24	87 10	30.10	+.25	+.16	+.02	—.04	+.34	+.35	+.36	+.35
Cincinnati	39 6	84 27	29.26	+.29	+.25	—.13	—.64	+.21	+.47	+.49	+.24
Lexington	38 6	84 18	28.99	+.33	+.22	—.06	—.43	+.24	+.43	+.45	+.26
Springfield	39 53	83 48	28.94	+.33	+.16	—.05	—.54	+.08	+.36	+.45	+.26
Portsmouth	38 42	82 54	29.52	+.42	+.23	—.02	—.52	+.16	+.48	+.55	+.23
Marietta	39 25	81 36	29.44	+.41	+.37	+.02	—.37	+.06	+.30	+.55	+.34
Savannah	32 5	81 5	30.26	...	...	+.14	—.11	—.11	+.11	+.54	+.44
Indian Key	24 48	80 55	30.16	+.15	+.07	+.04	+.08	+.08	+.13	+.26	+.13
Steubenville	40 25	80 40	29.45	+.39	+.31	+.12	—.35	—.08	+.27	+.46	+.31
Rochester	43 8	77 51	29.48	+.49	+.48	+.30	+.06	—.45	+.02	+.40	+.47
Washington	38 53	77 00	29.90	+.57	+.52	+.38	+.03	—.41	+.10	+.55	+.46
Sunbury	40 53	76 50	29.47	+.63	...	+.48	+.06	—.37	...	+.63	+.53
Baltimore	39 18	76 37	30.05	+.59	+.53	+.41	—.05	—.44	+.27	+.58	+.46
Syracuse	43 1	76 16	29.59	+.61	+.53	+.35	—.04	—.36	+.20	+.47	+.51
Philadelphia	39 57	75 10	29.90	+.60	+.60	+.55	+.17	—.39	+.10	+.54	+.64
New York	40 43	74 00	30.14	+.61	+.65	+.56	+.23	—.34	+.12	+.50	+.57
Flushing	40 45	73 52	29.97	...	...	...	...	—.34	+.08	+.57	+.62
Albany	42 39	73 44	30.00	+.69	+.62	+.53	+.20	—.50	+.08	+.51	+.55
Montreal	45 31	73 35	29.89	+.60	+.58	+.52	+.24	—.55	+.01	+.46	+.65
New Haven	41 18	72 55	30.05	...	...	...	...	—.20	+.05	+.52	+.64
Hanover	43 42	72 18	29.55	+.57	+.69	+.61	+.42	—.19	+.02	+.41	+.62
Quebec	46 49	71 12	29.54	...	...	+.97	+.71	—.14	—.09	+.72	...
Boston	42 21	71 3	29.98	+.50	+.53	+.60	+.38	.00	—.01	+.37	+.54
New Bedford, C.	41 38	70 55	30.17	+.54	+.65	+.59	+.40	—.05	—.07	+.41	+.55
" R.	41 38	70 55	30.03	...	...	+.63	+.40	—.09	—.04	+.40	+.55
Gardiner	44 10	69 50	29.94	+.50	+.70	+.66	+.57	+.14	—.29	+.40	+.60
Halifax	44 39	63 36	29.85	+.05	+.45	+.45	+.60	+.35	—.05	—.15	—.05
Bermuda	32 34	64 38	30.02	+.43	+.52	+.58	+.52	+.45	+.34	+.20	+.03
St. Johns	47 34	52 38	29.74	—.39	—.20	+.28	+.65	+.71	+.69	+.39	+.12

In accordance with the preceding numbers, the lines of equal barometric disturbance have been drawn upon the five accompanying charts for Dec. 19th, 8 P. M.; Dec. 20th, 8 A. M. and 8 P. M.; and Dec. 21st, 8 A. M. and 8 P. M. On each chart is drawn the line of mean pressure, as well as the line of two-tenths of an inch *below* the mean; two-tenths of an inch *above* the mean, etc. On each of these maps there appears a large area over which the barometer was below its mean height. For convenience we will call this area the area of *low barometer*. On the evening of December 20th this area of low barometer was 980 miles from west to east; on the morning of December 21st it was 770 miles from west to east; and on the evening of December 21st it was 650 miles from west to east. It is evident that towards the north, the area of low barometer extended much beyond the limit of the maps. The greatest observed depression of the barometer (.72 inch) was at Quebec, in latitude 46° 49′; whence it is inferred that the area of low barometer probably extended as far north as it did south of Quebec. On this supposition, the area of low barometer December 21st extended about 3,000 miles from north to south. This area constituted an oblong oval figure whose length was from two to three times its breadth. This figure was not stationary, but travelled constantly eastward.

If the observations embraced the entire area of the storm, we could easily determine the approximate centre of the area of low barometer, and thus assign the direction and velocity of its motion from day to day. But unfortunately few, if any, observations have been obtained from points north of the centre of the storm. At Fort Snelling, near latitude 45° on the Mississippi river, the entire oscillation of the barometer from the lowest point on the 20th to the highest on the 21st was .67 inch. At Natchez the oscillation was .74 inch, and at New Orleans .61 inch. It may then be inferred that along the valley of the Mississippi river, the centre of the area of low barometer was near St. Louis. But the greatest depression of the barometer anywhere observed was at Quebec. Assuming St. Louis and Quebec to lie upon the central path of the area of low barometer, the direction of its progress was from S. 60° W. to N. 60° E. There can be little doubt that the barometric wave travelled towards some point north of east, and not towards the south of east, as has been inferred by Messrs. Hare and Espy. From the morning of Dec. 20th to the morning of December 21st, the centre of the storm advanced in the direction already assigned 1050 miles, being an average velocity of 44 miles per hour.

Observations of the Thermometer.

The following table presents a summary of the observations of the thermometer at most of the stations. Column first shows the names of the stations; columns second and third their latitude and longitude; and column fourth the mean temperature at each station for the month of December. The mean temperature for the given hours of observation was obtained by applying to the mean temperature of the month a correction for the hour of the day as determined by hourly observations made at Montreal and Philadelphia. This result was subtracted from the observed temperature, and the remainder indicated the number of degrees by which the observed temperature differed from the mean temperature for that hour of December. The fluctuations of the thermometer were required for 8 A. M. and 8 P. M. of each day; and whenever these hours did not correspond to the actual hours of observation at any station, the fluctuations for these hours were interpolated by a comparison of the preceding and subsequent observations. The results are inserted in columns five to twelve, which accordingly show how much the thermometer was above or below its mean height for the dates given at the top of the table:—

STATIONS.	Latitude.	Longitude.	Mean temp. of Dec.	THERMOMETRIC FLUCTUATIONS.							
				DECEMBER 19TH.		DECEMBER 20TH.		DECEMBER 21ST.		DECEMBER 22D.	
				8 A. M.	8 P. M.	8 A. M.	8 P. M.	8 A. M.	8 P. M.	8 A. M.	8 P. M.
Fort Gibson . . .	35° 48′	95° 15′	40°.8	+ 7°	— 4°	—13°	—30°	—27°	—21°	—10°	+ 4°
Fort Leavenworth . .	39 21	94 44	29.8	+ 6	+ 4	—30	—33	—33	—22	— 6	+ 2
Fort Towson . . .	34 00	95 33	42.6	+ 3	+ 8	+ 3	—24	—29	—18	—15	+ 1
Fort Jessup . . .	31 33	93 32	49.7	+ 3	+ 8	+18	—12	—29	—22	—24	—10
Fort Snelling . . .	44 53	93 12	16.9	+ 9	+ 7	—15	—25	—35	—35	—19	— 9
Fort Des Moines . .	41 32	93 38	29.2	— 1	+11	+ 5	—28	—35	—31	—16	0
Baton Rouge . . .	30 26	91 18	54.1	—16	+ 1	+ 9	— 2	—29	—24	...	...
Natchez	31 34	91 24	49.3	— 7	+ 3	+14	— 7	—24	—22	—20	—14
Fort Crawford . . .	43 5	91 00	22.6	+ 4	+12	+15	—23	—35	—29	—21	— 2
Augusta	40 12	91 6	28.4	— 3	+10	+12	—33	—38	—31	—19	— 2
St. Louis	38 37	90 15	33.7	0	+ 8	+ 8	—27	—32	—23	—17	— 1
New Orleans . . .	29 57	90 00	55.7	—10	0	+ 9	— 2	—22	—22	—27	—20
Fort Winnebago . .	43 31	89 28	21.3	+ 1	+ 8	+14	—22	—35	—37	—24	— 5
Fort Howard . . .	44 30	88 5	21.0	+ 4	+ 7	+17	+ 8	—22	—29	—22	— 3
Pensacola	30 24	87 10	55.6	—10	+ 3	+10	+10	—22	—24	—31	—17
Fort Mitchell . . .	32 19	85 2	52.0	—23	+ 4	+ 2	+ 9	—19	—14	—30	—13
Fort Mackinac . . .	45 51	84 33	23.1	— 1	+ 3	+14	+16	—16	—20	—22	—12
Cincinnati . . .	39 6	84 27	34.1	—23	+ 6	+10	+17	—25	—24	—28	—12
Fort Brady . . .	46 30	84 43	21.5	— 1	+ 3	+14	+15	—11	—20	—28	—13
Lexington . . .	38 6	84 18	36.5	—12	+ 2	+10	+15	—15	—25	—15	—14
Springfield . . .	39 53	83 48	30.8	—17	+ 3	+11	+13	—22	—27	—26	—17
Dearbornville . . .	42 24	83 2	26.9	— 9	+ 4	+ 8	+14	—25	—30	—32	—15
Portsmouth . . .	38 42	82 54	37.9	—22	— 2	+ 4	+12	—19	—18	—19	—14
Fort Gratiot . . .	42 55	82 23	26.6	— 8	+ 5	+11	+17	—20	—25	—23	—12
Marietta	39 25	81 36	34.6	—24	— 7	+ 9	+17	—16	—21	—25	—19
St. Augustine . . .	29 48	81 35	57.2	0	0	+ 5	+ 8	+ 7	—11	—23	—11
Twinsburg . . .	41 20	81 26	30.0	—18	+ 1	+10	+11	—14	—27	—26	— 7
Savannah	32 5	81 5	52.1	...	...	+ 6	+11	+10	— 6	—12	—13
Indian Key . . .	24 48	80 55	70.7	— 1	+ 2	+ 4	+ 5	+ 2	— 3	—10	— 1
Steubenville . . .	40 25	80 40	30.8	—19	— 6	+ 1	+10	—10	—21	—20	—17
Alleghany Arsenal . .	40 32	80 2	31.3	—26	—10	—10	+10	—11	—20	—25	—21
Charleston . . .	32 46	79 56	51.8	— 9	—15	+ 4	+13	+ 6	—14	—21	—17
Pomfret	42 26	79 24	30.8	—13	— 4	— 2	+12	—11	—19	—19	—16
Lewiston	43 9	79 10	29.7	—14	— 3	+ 3	+10	—13	—20	—27	—14
Rochester	43 8	77 51	28.6	—10	— 4	— 1	+13	— 2	—18	—21	—17
Washington . . .	38 53	77 00	37.3	—12	— 7	— 4	0	+ 8	—13	—24	—13
Sunbury	40 52	76 49	30.6	—22	...	—12	+ 2	+12	—17	—22	—15
Baltimore	39 18	76 37	35.0	—12	— 8	— 5	+ 2	+18	—12	—18	—13
Fort Monroe . . .	37 00	76 18	43.1	— 9	— 7	0	+ 6	+13	—11	—18	—21
Syracuse	43 1	76 15	29.1	— 7	— 8	0	+14	+ 3	—18	—21	—19
Ellisburg	43 45	76 10	25.9	— 2	+ 3	— 1	+10	+10	—10	—13	—12
Gouverneur . . .	44 25	75 35	20.0	— 6	+ 5	+ 3	+17	+ 6	— 9	—13	— 9
Utica	43 7	75 13	26.8	—17	— 6	—10	+ 8	+23	—14	—17	—18
Philadelphia . . .	39 57	75 10	34.4	—14	— 9	— 9	+ 4	+22	— 9	—21	—23
Potsdam	44 40	75 1	22.1	...	...	...	...	+16	—10	—16	—12
New York	40 43	74 00	33.5	+ 8	— 5	— 4	+ 8	+20	— 6	—14	—14
Albany	42 40	73 45	28.4	—10	— 2	—12	+11	+24	—12	—14	—16
Montreal	45 31	73 35	18.6	+ 3	+ 5	+ 8	+16	+29	— 2	— 8	—10
Granville	43 20	73 17	24.8	— 5	+ 2	—10	+ 1	+20	—11	—11	— 1
New Haven . . .	41 18	72 55	33.0	—14	—10	—15	+11	+22	— 2	—15	—16
Hanover	43 43	72 18	17.8	—11	— 3	— 9	+15	+26	+ 2	— 8	—13
Quebec	46 49	71 12	15.0	...	...	+10	+ 7	+25	+ 1	—11	...
Boston	42 21	71 3	30.3	— 6	— 2	— 3	+13	+20	— 2	—12	—13
New Bedford . . .	41 38	70 55	32.3	— 7	— 5	— 4	+10	+16	— 2	—15	—16
East Hampton . . .	41 00	70 19	33.4	— 9	— 6	— 9	+10	+19	+ 6	—15	— 5
Gardiner	44 10	69 50	25.3	—13	—10	— 9	+15	+20	+ 8	— 8	—15
Hancock Barracks . .	46 7	67 49	18.1	—10	— 1	—14	+ 1	+21	+17	— 8	—12
Halifax	44 39	63 37	27.7	— 6	— 6	— 8	+ 2	+ 9	+ 8	+ 4	—11
Bermuda	32 34	64 38	60.6	— 8	— 1	+ 3	+ 2	+ 3	+ 2	+ 3	— 2
St. Johns	47 34	52 38	25.3	+ 1	— 2	— 4	— 2	— 6	— 6	+ 6	+ 2

In accordance with the preceding numbers, the lines of equal thermometric disturbance have been drawn upon the five accompanying charts. On each chart is drawn the line of mean temperature, and on most of them are drawn lines of ten, twenty, and thirty degrees *below* the mean, as well as lines of ten, etc., degrees *above* the mean. On each of these maps, there appears a large area over which the thermometer was above its mean height. For convenience we will call this area the area of *high thermometer.* On the evening of December 19th this area of high thermometer extended from 800 to 1,100 miles in an east and west direction; but at only three places did the thermometer rise as high as ten degrees above the mean. December 20th the area of high thermometer near the parallel of 40° had contracted to a breadth of 570 miles, and at several places the thermometer stood more than fifteen degrees above the mean. On the morning of the 21st the thermometer at several places stood more than twenty degrees above the mean. Thus it appears that near the centre of the storm the heat had increased about fifteen degrees in thirty-six hours, from the evening of the 19th to the morning of the 21st.

The centre of this area of high thermometer did not coincide with the centre of the area of low barometer, but was uniformly somewhat to the eastward of it. On the morning of December 20th, near the parallel of 40°, the point of greatest heat was considerably eastward of the centre of the area of rain and snow, and was about 400 miles east of the point of least barometric pressure. On the evening of December 20th, near the parallel of 44°, the point of greatest heat was about 350 miles east of the point of least pressure, and this last point coincided nearly with the centre of the area of rain and snow; while on the morning of December 21st, near the parallel of 46°, the point of greatest heat was about 200 miles east of the point of least pressure. On the eastern side of the storm, where the rain had not yet commenced, the thermometer stood twenty degrees above its mean height; while on the western margin of the storm the thermometer sunk below its mean height before the rain and snow had ceased. On the evening of December 21st the points of greatest heat and of least pressure probably differed but little in position.

Face of the Sky.

On the five accompanying charts, the face of the sky has been represented by colors in accordance with the original observations, of which the most important particulars are given in my article published in the *Transactions of the American Philosophical Society*, vol. vii. pp. 133–137. From these charts it will be seen that on the evening of December 19th rain or snow was falling throughout the entire region west of the Mississippi, as far as the map extends, and the cloud covered the entire United States, except those States bordering on the Atlantic Ocean. On the morning of the 20th the rain and snow had extended eastward as far as Cincinnati, and the cloud covered the entire United States, except New York and New England. On the evening of the 20th the rain had extended eastward to Washington, while only a small portion of New England was free from cloud. The boundary of the rain and snow on the west now comes within the limits of the chart, and an area of clear sky appears beyond Arkansas and Louisiana. On the morning of the 21st the cloud has covered the whole of the eastern portion of the chart, while the western portion is left unclouded as far as Cincinnati. The rain now covers the whole of New England, except the State of Maine, while the western boundary of the rain and snow has reached the middle of Lake Erie. On the evening of the 21st the storm is confined to the eastern margin of the chart, while the western boundary of the rain has passed to the east side of the Connecticut river; and throughout the whole of the United States, except New England and two or three small spots of limited extent, the sky is entirely free from clouds.

Throughout the entire United States the average amount of rain which fell during this storm was seven-eighths of an inch, and although the fall at different places was very unequal, still the average amount was sensibly the same on the eastern as on the western part of the country, and on the north side nearly equal to that on the south side.

Direction of the Wind.

On the accompanying charts the direction of the wind has been indicated by arrows, according to the observations given in my first memoir, pp. 137–139. It will be seen that on the evening of the 19th, throughout the area of rain and snow as far as it is exhibited on the chart, the wind blew from the south or southeast. On the east side of the boundary of rain and snow, but within the limits of the cloud, the winds appear to be somewhat influenced by the storm; but in New England the winds blow from about their normal direction; that is, from the west, inclining somewhat to the northwest.

On the morning of the 20th, beyond the Mississippi river, the winds had changed to the north and northwest; but on the eastern half of the area of rain and snow the prevalent direction of the winds was from the southeast. For some distance beyond the boundary of the rain on the east, the winds inclined towards the southeast, while along the northeast border of the United States the winds were generally from the southwest; but they were light, and in some places changing to northeast.

On the evening of the 20th, beyond the meridian of Chicago, the winds everywhere blew from the north or northwest. Throughout all the remaining part of the United States, with here and there a solitary exception, the winds blew from some southern quarter, and the prevalent direction was from a point a few degrees east of south.

On the morning of the 21st, on the west side of the centre of the storm, the winds were generally from the west and northwest; the prevalent direction being from a point a few degrees north of west. On the east side of the centre of the storm, the winds were generally from the south and southeast, the prevalent direction being from a point a little east of south.

On the evening of the 21st, throughout the extreme western part of the United States, the winds were becoming less northerly than in the morning; but in the neighborhood of the storm, on the west side of its centre, the winds continue from the west and northwest; the prevalent direction being about thirty degrees north of west; while on the east side of the centre the winds are from the south and southeast.

It will thus be seen that during the entire period in question, within the area of rain and snow, the direction of the winds was quite uniform. In the rear of the storm the winds blew from the west, northwest, or north; the average direction being thirty degrees north of west; and in the southwest part of the United States the winds were somewhat more northerly than in the northwest part of the country. In front of the storm the winds generally blew from some southerly point. The average direction was ten degrees east of south; and in the south part of the United States the winds were quite as much easterly as in the north part of the country.

We thus find that along a meridian line, for a distance of at least 1,200 miles, we have on the west side a violent current setting from a point thirty degrees north of west; and on the east side, in close proximity, we have also a strong current setting from a point ten degrees east of south. These two currents blew with great violence for at least forty-eight hours, in directions inclined to each other one hundred and thirty degrees. It must be remembered that our observations are confined to the southern half of this storm, and that in order to discover what law the winds observed, it is important to have observations from every side of the centre of the storm. The observations here presented indicate a decided crowding of the winds towards the centre of the storm, and also some tendency to circulate around the centre, in a direction contrary to the motion of the hands of a watch; but this storm was so much elongated that the direction of the winds cannot be even approximately represented by circles, whose centre is at the point of greatest barometric depression.

Origin of the Storm.

This storm probably commenced not far to the west of the Mississippi river, and its origin is to be ascribed to the high barometer prevailing along the eastern part of the United States. This high barometer caused the wind on the eastern side of the Mississippi river to flow westward. This easterly current was opposed by the normal west wind, which prevailed at places further west. The west wind flowed under the east wind, by which means the latter was lifted up above the earth's surface, and its vapor was condensed by the cold of elevation. This condensed vapor descended in the form of rain or snow, according to the temperature of the place. The heat liberated in the condensation of this vapor expanded the upper stratum of air, causing it to rise above its ordinary elevation, and thus to flow off above, causing a diminished pressure at the earth's surface, so that throughout the area of rain and snow the barometer fell below its mean height. This fall of the barometer increased the strength of the east wind which set in from the eastern part of the United States, and this being forced upward from the earth's surface by the west wind which prevailed on the western side of the storm, caused a still greater precipitation of moisture, which liberated a greater amount of heat, and increased still further the fall of the barometer. A portion of the air which flowed off above from the region of the storm spread eastward, and increased the pressure over the eastern portion of the United States, thus adding to the strength of the east wind which blew upon the eastern side of the storm.

The air which thus spread eastward in advance of the storm was heated by the caloric liberated in the condensation of the vapor, and this probably occasioned the rise of the thermometer in front of the storm, which was particularly noticeable on the morning of the 21st.

From the evening of December 19th to the evening of the 21st the phenomena remained sensibly the same, except that the storm had drifted steadily eastward, being borne along by the strong west wind; and since this west wind was more violent than the southeast wind, the partial vacuum prevailing under the storm was gradually filling up, and after two or three days more it had nearly disappeared.

What was the Cause of the extreme Cold which succeeded this Storm?

On the morning of December 20th, near St. Louis, the thermometer stood at its mean height. At the same place, on the evening of the same day, the thermometer had fallen to thirty degrees *below the mean;* being a descent of thirty degrees in twelve hours, independent of the diurnal variation.

This cold cannot be ascribed to radiation, for the change took place under the cloud, and even before snow had entirely ceased falling. A portion of the effect may be ascribed to the transfer of air from a higher to a lower latitude. The wind had blown with a probable velocity of sixty miles per hour for twelve hours, during which time it must have advanced 720 miles towards the southeast, or about 500 miles in the direction of a meridian, which is equivalent to about seven degrees of latitude, and corresponds to a change of temperature of about eighteen degrees. But a portion of this cold would be lost during the transfer to a warmer latitude, so that we cannot ascribe to a change of latitude an effect greater than twelve or fifteen degrees.

This cold air being somewhat warmed during its progress southward, is thereby rendered relatively dryer; and this dryness accelerates the evaporation of the moisture upon the earth's surface. This evaporation begets cold on the evaporating surface; and this cold is shared in part by the air in contact with the earth's surface. This cause must tend in some degree to check the increase of temperature which the air would otherwise experience in its transfer to a warmer latitude; but I do not ascribe to this cause any powerful effect. There still remains to be accounted for a depression of the thermometer amounting to about fifteen degrees.

I believe that this cold current came from the upper stratum of the atmosphere; and that the upper part of the atmosphere, when brought down to the level of the sea, is generally colder than the average temperature of the earth's surface. According to the theory of Dalton, the atmosphere can only be in a state of equilibrium when a pound of air, at all distances above the earth's surface, contains the same quantity of heat. Under such circumstances, if air be brought down from the top of a mountain, by coming under increased pressure it must acquire exactly the temperature of the air which was previously at the base of the mountain. But such an equilibrium is seldom, if ever, attained in nature. The heat which is liberated during a great fall of rain or snow increases the temperature of the upper air; and if this air could be suddenly brought down to the earth's surface, it might be found even warmer than the ordinary temperature of the earth's surface. But generally, under a clear and tranquil sky, the reverse must be true.

The atmosphere receives heat from the sun, and loses its heat by radiation. It is estimated that in clear weather the atmosphere absorbs only about one-fourth of the rays of the sun which traverse the atmosphere vertically. The remaining rays are received upon the earth's surface, by which the earth is heated, and this heat is thence communicated to the air which rests upon the earth. The heat which the atmosphere receives is, therefore, chiefly applied to its lower stratum. This heat is all lost by radiation; for otherwise the mean temperature of the earth would be continually increasing. The rate at which a hot body loses its heat by radiation, is proportional to the difference between its own temperature and that of the surrounding medium. Suppose, then, that a pound of air at the top and bottom of the atmosphere contained the same amount of heat, the upper atmosphere having on one side a void space whose temperature is many degrees below zero, would lose its heat much more rapidly than the lower portion of the atmosphere. The atmosphere, then, receives its heat chiefly at the bottom, and loses it most rapidly at the top. The top must, therefore, ordinarily be the coldest, and such would still be the case, though the atmosphere had throughout the same density. In a clear and tranquil time, a pound of air at the earth's surface must, therefore, contain more heat than a pound of air on the summit of a mountain; and if air from the summit of the mountain could be made suddenly to displace the air at the level of the sea, it would feel colder than the latter. Such a condition of the atmosphere is at best one of unstable equilibrium, and the lower strata tend continually to rise and take the place of the upper. Such a motion is indicated nearly every pleasant day, by the formation of cumulus clouds soon after the rising of the sun, and their disappearance on the approach of evening. More violent and extensive disturbances of this equilibrium take place in thunder-gusts and tornadoes, when large masses of air from the earth's surface are pressed upwards with great violence, and their place is occupied by air from the upper strata; and the uniform effect of such an interchange of air is a considerable reduction of temperature at the earth's surface. After a few days' continuance of pleasant weather, the lower air again becomes much warmer than the upper air, and another somerset takes place, accompanied by a like reduction of temperature.

EUROPEAN STORM OF DECEMBER 21-28, 1836.

Observations of the Barometer.

The following table presents a summary of the observations of the barometer at each of the European stations from which reports have been received. Column first shows the name of the station; columns second and third their latitude and longitude; and column fourth the mean height of the barometer at each station. The numbers in this column are in most cases derived from observations continued through a series of several years, and represent the mean height of the barometer with tolerable accuracy; but at some of the stations the mean height of the barometer is only approximately determined. Columns five to twelve furnish the difference between the mean height of the barometer and the height observed at noon for each day from December 21st to December 28th. At some of the stations no observation was made precisely at noon, and in such cases the barometric fluctuation was computed by a comparison of the preceding and subsequent observations:—

STATIONS.	Latitude.	Longitude.	Mean height.	BAROMETRIC FLUCTUATIONS.							
				Dec. 21. Noon.	Dec. 22. Noon.	Dec. 23. Noon.	Dec. 24. Noon.	Dec. 25. Noon.	Dec. 26. Noon.	Dec. 27. Noon.	Dec. 28. Noon.
			Inches.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.
Upernivik	72° 48′	55° 53′W.	29.78	+.55	+.10	+.24	+.22	+.20	+.14	—.39	—.67
Reykiavig	64 8	21 55 W.	29.54	+.69	+1.13	+1.33	+1.12	+.92	+.67	+.63	+.48
St. Petersburg	59 56	30 18 E.	29.96	—.38	—.38	—.33	—.15	+.22	+.53	+.42	+.44
Christiania	59 54	10 44 E.	29.76	—.07	+.15	+.17	+.53	+.80	+.88	+.58	+.53
Sandwick	59 5	3 17 W.	29.46	+.26	+.16	+.24	+.64	+.74	+.62	+.62	+.62
Riga	56 57	24 6 E.	29.98	—.10	—.37	—.39	—.13	+.25	+.38	+.20	+.17
Catherinenburg	56 50	60 34 E.	29.03	—.41	—.43	—.35	—.50	—.63	—.26	+.05	+.15
Edinburgh	55 57	3 11 W.	29.64	+.33	+.36	+.19	+.31	+.39	+.39	+.22	+.36
Moscow	55 45	37 38 E.	29.22	—.38	—.54	—.80	—.55	—.11	+.23	+.22	+.12
Konigsberg	54 42	20 29 E.	29.90	+.05	—.14	—.63	—.06	+.24	+.15	—.02	+.04
Danzig	54 21	18 41 E.	29.95	+.22	+.08	—.49	+.10	+.31	+.25	+.25	+.15
Stralsund	54 19	13 5 E.	29.88	+.21	+.21	—.48	—.02	+.13	—.01	—.06	—.02
Altona	53 32	9 56 E.	29.87	+.16	+.08	—.36	—.15	—.06	—.20	—.15	—.04
Dublin	53 23	6 11 W.	29.73	+.44	+.50	+.23	+.19	+.28	+.15	+.06	+.29
Swislotsch	53 2	24 5 E.	29.06	+.21	—.35	—.50	—.28	—.13	—.05	+.04	+.04
Boston	52 48	0 5 E.	29.60	+.23	+.31	—.20	—.10	—.05	—.12	—.20	+.04
Berlin	52 30	13 24 E.	29.94	+.13	+.06	—.87	—.30	—.27	—.39	—.34	—.21
Thwaite	52 24	1 0 E.	29.80	+.55	+.62	+.07	+.05	+.07	—.06	.00	+.24
Harlem	52 23	4 39 E.	29.83	+.37	+.38	—.19	—.14	—.19	—.29	—.23	—.03
Warsaw	52 13	21 1 E.	29.53	+.17	—.12	—.78	—.13	+.04	—.11	—.22	—.08
Cambridge	52 13	0 6 E.	29.87	+.41	+.48	—.02	—.11	—.05	—.21	—.19	+.04
Oxford	51 45	1 16 W.	29.71	+.44	+.48	—.01	—.09	—.04	—.23	—.21	+.09
Koursk	51 44	36 11 E.	29.27	+.02	—.16	—.53	—.60	+.11	+.20	+.04	—.20
London	51 28	0 5 W.	29.83	+.45	+.49	—.02	—.10	—.10	—.27	—.21	+.06
Cologne	50 56	6 58 E.	29.80	...	+.35	—.23	—.31	—.40	—.45	—.27	—.27
Brussels	50 51	4 22 E.	29.76	+.36	+.39	—.22	—.31	—.39	—.50	—.31	—.12
Neisse	50 28	17 20 E.	29.26	+.40	+.22	—.51	—.16	—.16	—.22	—.23	—.07
Prague	50 5	14 25 E.	29.22	+.39	+.29	—.50	—.26	—.45	—.53	—.32	—.19
Cracow	50 4	19 51 E.	29.24	+.20	—.05	—.65	—.31	—.33	—.47	—.42	—.28
Paris	48 50	2 20 E.	29.76	+.30	+.40	—.24	—.47	—.51	—.60	—.42	—.16
Vienna	48 12	16 23 E.	29.34	+.24	+.10	—.37	—.44	—.49	—.66	—.44	—.34
Munich	48 8	11 36 E.	28.28	+.20	+.15	—.41	—.72	—.87	—.92	—.58	—.49
Peissenberg	47 48	11 1 E.	26.66	+.19	+.18	—.34	—.69	—.81	—.86	—.53	—.47
Buda	47 29	19 3 E.	29.11	+.36	+.13	—.27	—.29	—.31	—.49	—.31	—.24
Zurich	47 23	8 32 E.	28.53	...	+.27	—.20	—.70	—.78	—.77	—.50	—.39
Geneva	46 12	6 10 E.	28.60	...	+.31	—.09	—.68	—.75	—.68	—.48	—.34
St. Bernard	45 50	6 6 E.	22.19	+.16	+.17	—.20	—.68	—.83	—.83	—.64	—.53
Milan	45 28	9 11 E.	29.64	+.17	+.08	—.33	—.72	—.97	—.92	—.60	—.49
Padua	45 24	11 52 E.	29.94	+.21	+.14	—.24	—.64	—.81	-1.01	—.58	—.42
Bologna	44 30	11 21 E.	29.71	+.23	+.15	—.22	—.62	—.85	—.84	—.56	—.43
Orange	44 7	5 50 E.	29.84	+.17	+.15	—.09	—.64	—.77	—.66	—.58	—.44
Florence	43 47	11 15 E.	29.75	+.16	+.10	—.13	—.61	—.84	—.74	—.52	—.47
Toulouse	43 36	1 28 E.	29.49	+.28	+.29	+.01	—.68	—.59	—.70	—.62	—.31
Marseilles	43 17	5 22 E.	29.81	+.23	+.19	—.06	—.60	—.77	—.60	—.60	—.43
Rome	41 54	12 25 E.	29.84	+.15	+.13	+.01	—.38	—.64	—.56	—.38	—.35
Naples	40 51	14 15 E.	29.44	+.09	+.18	+.05	—.24	—.41	—.49	—.29	—.24
Cadiz	36 32	6 18 W.	29.84	+.07	+.12	+.02	—.25	—.24	—.22	—.25	—.26

In accordance with the preceding numbers, the lines of equal barometric disturbance have been drawn upon the eight accompanying charts from December 21st to December 28th. On each chart is drawn the line of mean pressure; also the line of a quarter inch elevation *above* the mean, and one-half inch above the mean; and also the line of a quarter inch depression *below* the mean. On six of the charts is drawn the line of a half inch depression below the mean, and on three of them the line of three-quarters of an inch below the mean.

On the 21st of December the barometer was above its mean height throughout the whole of Europe, except its northeastern portion, and here the greatest observed depression was .41 inch. On the 22d the depression of the barometer near the centre of Russia had increased to a half inch, and the area of low barometer had extended somewhat further towards the south. On the 23d the area of low barometer had extended so as to cover nearly the whole of Europe, comprehending the whole of France, and more than half of Italy; while the area of one-half inch depression below the mean formed an oval figure, whose longer diameter was 1,750 miles, and its shorter diameter over 500 miles. On the 24th the area of low barometer covered all of Europe, except its extreme northern portion, and there are two areas of one-half inch depression; one having its centre near Switzerland, and the other in Central Russia. The former area was an oval 870 miles long and 560 broad, while the latter was 1330 miles long and 520 broad. On the 25th the Swiss area of a half inch barometric depression had somewhat extended its limits, being now 980 miles long and 830 broad; while the Russian area had travelled towards the northeast, and had nearly reached the eastern limit of Europe. On the 26th the Swiss oval of one-half inch depression had increased still further in its dimensions, being now 1150 miles long and 930 broad; while the Russian oval of one-half inch depression had passed beyond the limits of Europe. On the 27th the Swiss oval had greatly contracted in its dimensions, being now only 890 miles long and 400 miles broad. On the 28th the area of one-half inch depression below the mean had almost entirely disappeared, and the area of one-quarter of an inch depression had contracted very much in its dimensions.

The Swiss area of low barometer on the 24th probably had a different origin from that of the low barometer which prevailed throughout Eastern Europe on the 23d. The latter travelled towards the northeast from December 23d to December 25th, at the rate of about 40 miles per hour. The former probably originated in Western Europe, and its centre remained nearly stationary for four entire days, viz., from noon of December 24th to noon of December 28th, and this centre was at no time more than 140 miles from Mount Blanc, in Switzerland, being uniformly a little south of that mountain peak.

Observations of the Thermometer.

The following table presents a summary of the observations of the thermometer at the several stations. Column first shows the names of the stations; columns second and third their latitude and longitude; and column fourth shows the mean temperature of each station for the month of December. The mean temperature at noon for the month of December was obtained by applying to the mean temperature of the month a correction deduced from hourly observations at numerous stations in Europe. The mean temperature at noon was subtracted from the observed temperature, and the remainders are given in columns five to twelve. These remainders, therefore, show the number of degrees by which the temperature observed at noon of each day differed from the mean temperature of the station at that hour. At some of the stations no observations were made at noon, and in such cases the thermometric fluctuation was interpolated by a comparison of the preceding and subsequent observations:—

STATIONS.	Latitude.	Longitude.	Mean temp. of Dec.	THERMOMETRIC FLUCTUATIONS.							
				Dec. 21. Noon.	Dec. 22. Noon.	Dec. 23. Noon.	Dec. 24. Noon.	Dec. 25. Noon.	Dec. 26. Noon.	Dec. 27. Noon.	Dec. 28. Noon.
Reykiavig	64° 8′	21° 55′W.	29°.4	— 7°	—13°	—18°	— 7°	— 1°	+ 4°	+ 8°	+ 7°
Yarensk	62 10	49 7 E.	—1.2	+35	— 1	— 1	— 6	—26	—17	—13	—37
St. Petersburg	59 56	30 18 E.	21.6	+10	0	— 4	—22	—14	—16	—11	— 7
Christiania	59 54	10 44 E.	27.2	+ 1	—13	— 6	—19	—19	—17	—24	—11
Sandwick	59 5	3 17 W.	41.8	0	+ 3	—11	—12	—11	—12	—12	— 7
Riga	56 57	24 6 E.	27.5	+ 4	+ 1	—11	—13	—21	—20	—22	—23
Catherinenburg	56 50	60 35 E.	4.5	+12	+18	+16	+22	+12	—11	—27	—19
Edinburgh	55 57	3 11 W.	39.7	+ 6	+ 8	— 6	— 5	—11	— 9	— 6	— 9
Moscow	55 45	37 38 E.	17.1	+17	+12	— 3	— 8	— 7	—17	—22	—19
Konigsberg	54 42	20 29 E.	27.1	+11	+ 8	+ 2	— 7	— 9	—11	—14	—17
Danzig	54 21	18 41 E.	31.8	+ 8	+ 3	— 3	—11	—11	—14	—14	—14
Stralsund	54 19	13 5 E.	34.2	+ 7	+ 4	— 2	— 7	— 8	— 7	— 5	— 9
Altona	53 32	9 56 E.	39.3	+ 2	+ 1	— 9	—10	—15	—15	—17	—17
Dublin	53 23	6 11 W.	41.5	+ 5	+ 6	— 7	— 7	—10	—10	— 8	— 9
Swislotsch	53 2	24 5 E.	25.9	+14	+ 9	+ 5	— 8	—18	—10	— 6	—10
Boston	52 48	0 5 E.	39.9	— 1	0	— 3	— 8	—10	— 9	— 5	— 7
Berlin	52 30	13 24 E.	35.0	+ 5	+ 2	— 3	— 9	—14	—18	—17	— 6
Harlem	52 23	4 39 E.	38.2	+ 5	+ 8	+ 1	— 7	—10	—10	—15	— 8
Warsaw	52 13	21 1 E.	28.8	+ 8	+ 8	+ 6	—12	—13	—14	—13	—15
Cambridge	52 13	0 6 E.	39.7	+ 1	0	0	— 8	—12	— 8	— 7	— 7
Oxford	51 45	1 16 W.	39.3	+ 5	+ 2	— 2	— 7	—15	—11	— 6	— 8
Koursk	51 44	36 11 E.	18.9	+14	+11	+ 6	+13	—11	—11	—11	—11
London	51 28	0 5 W.	40.5	+ 5	+ 3	0	— 6	—12	—10	— 7	— 7
Cologne	50 56	6 58 E.	37.4	...	+10	+ 5	— 4	—13	—15	— 7	— 7
Brussels	50 51	4 22 E.	39.4	+ 3	+ 5	+ 1	—11	—17	—20	—19	—18
Neisse	50 28	17 20 E.	33.6	+ 2	+ 2	+ 6	— 7	—16	— 9	—12	—12
Prague	50 5	14 25 E.	33.5	+ 2	+ 6	+ 7	— 2	— 8	0	— 4	— 9
Cracow	50 4	19 51 E.	29.5	+ 3	+ 6	+ 8	— 1	— 9	0	— 6	— 7
Poltava	49 35	34 34 E.	22.8	+12	+ 5	+ 5	+ 9	— 4	— 4	— 4	— 4
Paris	48 50	2 20 E.	38.6	+ 7	+ 4	+ 2	— 8	—16	—17	—18	—18
Catherinoslov	48 28	35 5 E.	22.8	+ 7	0	+ 7	+15	+14	— 1	+ 5	+10
Vienna	48 12	16 23 E.	33.0	+ 2	+ 5	+ 7	— 6	— 1	+ 3	0	— 5
Munich	48 8	11 36 E.	34.9	— 7	— 1	0	—10	— 7	—11	—17	—14
Peissenberg	47 48	11 1 E.	31.1	— 3	— 2	— 4	— 9	—10	—14	—15	—16
Buda	47 29	19 3 E.	29.7	+ 3	+10	+ 6	0	+ 7	+11	+ 7	+ 5
Zurich	47 23	8 32 E.	33.2	...	0	+ 2	+ 1	— 4	— 6	—12	—10
Geneva	46 12	6 10 E.	34.9	...	— 1	0	— 2	— 4	—12	—17	—11
St. Bernard	45 50	6 6 E.	16.3	+11	+ 8	+ 9	— 1	+ 1	— 3	—16	— 8
Milan	45 28	9 11 E.	36.6	— 2	— 4	— 4	— 4	— 2	— 2	— 5	— 6
Padua	45 24	11 52 E.	38.4	0	— 3	— 7	+ 3	+12	+ 3	— 1	— 6
Bologna	44 30	11 21 E.	39.2	— 2	0	— 2	+ 7	+ 6	+ 2	— 6	— 9
Orange	44 7	5 50 E.	46.2	— 8	— 6	— 9	— 9	—14	—18	—20	—17
Florence	43 47	11 15 E.	45.5	— 1	— 4	—11	— 1	+ 4	— 6	—12	—10
Toulouse	43 36	1 28 E.	42.0	0	0	— 5	— 5	—14	—13	—12	—19
Marseilles	43 17	5 22 E.	47.1	— 4	— 5	— 7	— 5	—14	—18	—13	—16
Rome	41 54	12 25 E.	47.8	+ 3	— 2	— 7	+ 3	+ 3	— 6	— 5	— 2
Naples	40 51	14 15 E.	49.1	+ 2	+ 1	— 1	— 4	+ 3	— 7	— 3	— 5
Cadiz	36 32	6 18 W.	53.6	— 2	0	0	— 4	—10	— 8	— 8	— 8

In accordance with the preceding numbers, the lines of equal thermometric disturbance have been drawn upon the eight accompanying charts. On each chart is drawn the line of mean temperature. On seven of them is drawn the line of ten degrees *below* the mean; and on four of them is drawn the line of ten degrees *above* the mean. During most of the eight days, throughout the principal part of Europe, the thermometer was *below* its mean height; but on the 21st, throughout the whole of Europe, except the extreme northern and southern portions, the thermometer stood *above* its mean height. Throughout Central Europe the thermometer nowhere rose so high as ten degrees above the mean; but throughout a considerable part of European Russia the thermometer stood more than ten degrees above its mean height, and at one station it rose thirty-five degrees above the mean. On the 22d and 23d the area of ten degrees above the mean had contracted considerably in its dimensions; while on the north of Europe the thermometer had fallen ten degrees below the mean. On the 24th the line of mean temperature had moved somewhat to the southward; while the area of ten degrees below the mean included Norway, Sweden, and a considerable part of Northern Russia. On the 25th, throughout the whole of Europe, except its southeastern portion, the thermometer was below its mean height; and throughout most of Europe the thermometer stood from ten to twenty degrees below the mean. On the 26th, 27th, and 28th the area of low thermometer was somewhat further extended, covering the whole of Europe, except a small portion on the southeast; while throughout the principal part of Europe the thermometer stood more than ten degrees below the mean.

It is remarkable that while in the neighborhood of Switzerland from the 24th to the 28th of December the barometer stood from a half inch to an inch below its mean height, the thermometer in the same vicinity from the 25th to the 28th was from ten to twenty degrees below its mean height; and on the 26th and 27th the region of greatest barometric depression coincided nearly with that of greatest thermometric depression, being exactly the reverse of what usually occurs in the storms of the United States.

Face of the Sky.

The following table shows for each of the stations the face of the sky; that is, it shows at what stations snow was falling, and where rain was falling; where it was cloudy, but without rain or snow; and also at what stations the sky was free from clouds:—

Face of the Sky.

STATIONS.	Dec. 21. Noon.	Dec. 22. Noon.	Dec. 23. Noon.	Dec. 24. Noon.	Dec. 25. Noon.	Dec. 26. Noon.	Dec. 27. Noon.	Dec. 28. Noon.
Reykiavig	Clear	Clear	Clear	Clear	Cloudy	Cloudy	Rain	Rain
Yarensk	Snow	Cloudy	Snow	Snow	Cloudy	Clear	Cloudy	Clear
St. Petersburg	Snow	Snow	Cloudy	Cloudy	Clear	Cloudy	Cloudy	Cloudy
Christiania	Cloudy	Cloudy	Cloudy	Clear	Clear	Clear	Clear	Snow
Sandwick	Clear	Rain	Snow	Snow	Clear	Clear	Cloudy	Clear
Catherinenburg	Cloudy	Snow	Snow	Snow	Snow	Cloudy	Cloudy	Cloudy
Edinburgh	Clear	Rain	Cloudy	Snow	Snow	Cloudy	Snow	Cloudy
Moscow	Cloudy	Snow	Snow	Snow	Cloudy	Cloudy	Cloudy	Cloudy
Danzig	Cloudy	Cloudy	Snow	Cloudy	Cloudy	Snow	Snow	Cloudy
Stralsund	Cloudy	Cloudy	Snow	Snow	Snow	Snow	Cloudy	Cloudy
Altona	Cloudy	Rain	Rain	Snow	Snow	Snow	Snow	Snow
Dublin	Cloudy	Cloudy	Clear	Snow	Snow	Cloudy	Sleet	Cloudy
Swislotsch	Rain	Rain	Snow	Cloudy	Cloudy	Snow	Snow	Cloudy
Boston	Fine	...	Fine	Snow	Snow	Snow	Cloudy	Snow
Berlin	Cloudy	Cloudy	Snow	Snow	Snow	Snow	Snow	Snow
Harlem	Cloudy	Cloudy	Rain	Snow	Cloudy	Cloudy	Snow	Snow
Warsaw	Rain	Rain	Rain	Cloudy	Snow	Snow	Snow	Cloudy
Oxford	Cloudy	Cloudy	Rain	Snow	Snow	Snow	Snow	Cloudy
Koursk	Cloudy	Rain	Snow	Cloudy	Snow	Snow	Cloudy	Clear
London	Cloudy	Cloudy	Rain	Snow	Snow	Snow	Snow	Cloudy
Cologne	Cloudy	Cloudy	Rain	Snow	Snow	Cloudy	Cloudy	Snow
Brussels	Cloudy	Cloudy	Rain	Snow	Snow	Snow	Snow	Snow
Neisse	Cloudy	Cloudy	Rain	Snow	Snow	Cloudy	Cloudy	Cloudy
Prague	Cloudy	Cloudy	Rain	Snow	Snow	Cloudy	Cloudy	Snow
Cracow	Rain	Cloudy	Rain	Snow	Cloudy	Cloudy	Snow	Cloudy
Poltava	Cloudy	Cloudy	Cloudy	Cloudy	Cloudy	Snow	Snow	Cloudy
Paris	Cloudy	Fog	Rain	Snow	Snow	Snow	Cloudy	Snow
Catherinoslov	Cloudy	Cloudy	Cloudy	Cloudy	Cloudy	Snow	Cloudy	Cloudy
Vienna	Cloudy	Cloudy	Cloudy	Snow	Rain	Rain	Cloudy	Cloudy
Munich	Cloudy	Cloudy	Cloudy	Snow	Cloudy	Snow	Cloudy	Cloudy
Peissenburg	Clear	Cloudy	Cloudy	Snow	Cloudy	Cloudy	Cloudy	Cloudy
Buda	Cloudy	Cloudy	Cloudy	Cloudy	Rain	Cloudy	Cloudy	Cloudy
Zurich	...	Cloudy	Cloudy	Snow	Snow	Snow	Cloudy	Cloudy
Geneva	...	Cloudy	Cloudy	Snow	Snow	Cloudy	Cloudy	Cloudy
St. Bernard	Clear	Clear	Cloudy	Snow	Snow	Cloudy	Cloudy	Cloudy
Milan	Clear	Clear	Cloudy	Rain	Rain	Cloudy	Cloudy	Cloudy
Padua	Clear	Clear	Cloudy	Rain	Rain	Cloudy	Cloudy	Cloudy
Bologna	Clear	Clear	Cloudy	Rain	Rain	Cloudy	Cloudy	Cloudy
Orange	Clear	Clear	Cloudy	Rain	Cloudy	Cloudy	Snow	Snow
Florence	Clear	Cloudy	Clear	Rain	Rain	Rain	Rain	Cloudy
Toulouse	Cloudy	Cloudy	Cloudy	Rain	Snow	Cloudy	Snow	Snow
Marseilles	Clear	Clear	Cloudy	Rain	Cloudy	Cloudy	Snow	Snow
Rome	Clear	Cloudy	Cloudy	Rain	Rain	Rain	Rain	Rain
Naples	Clear	Clear	Clear	Rain	Rain	Rain	Rain	Rain
Cadiz	Cloudy	Cloudy	Cloudy	Cloudy	Cloudy	Cloudy	Cloudy	Cloudy

The preceding particulars have been represented by the aid of colors on the eight accompanying charts, in the manner already explained. By inspecting these charts it will be seen that from the 21st to the 28th of December, throughout nearly the whole of Europe, the sky was constantly covered with clouds. On the 21st there was a small region of unclouded sky on the northwestern part of Europe, and another on the extreme southern part. Throughout nearly the whole of Russia rain or snow was falling, but at a moderate rate; and throughout all the rest of Europe the sky was overcast, but without rain or snow.

On the 22d there still remained a small region of unclouded sky on both the northern and southern borders of Europe. The Russian area of rain and snow had moved somewhat to the southward; while a second area of rain covered most of England and Scotland, as also Holland and the North Sea. On the 23d these two regions of rain and snow had united; thus forming a continuous area of rain or snow, extending from Land's End to the Ural Mountains, a distance of at least 2,800 miles; but its average breadth from north to south did not exceed 500 miles.

At the same time snow was falling over a limited space about the Orkneys, on the north of Scotland.

On the 24th this long storm divided and formed two separate storms; while the eastern portion advanced towards the northeast; but the other storm now covered an area about 1,500 miles in diameter, its centre being over the eastern part of France. There is no longer any region of unclouded sky on the southern side of Europe, but only on the northern margin. On the 25th both storms occupied nearly the same position as on the preceding day. On the 26th the Russian storm had passed beyond the limits of Europe, or had disappeared entirely; while the great storm of Western Europe had broken up into three separate areas of rain or snow; and in the southern part of Russia there appeared a new area of snow.

On the 27th, between the parallels of 50 and 56 degrees, we find a continuous belt of snow extending from east to west a distance of 2,000 miles, and a somewhat smaller area of rain and snow on the south of Europe; while a new area of rain appears in the neighborhood of Iceland. On the 28th the phenomena are generally similar to those of the 27th; but the snow area of Central Europe is now only about 900 miles from east to west; while a fourth area of snow appears in Sweden. The storm-cloud may now be said to extend over the whole of Europe; but in many places this cloud was thin, and at three stations the sky was left entirely uncovered.

It is desirable to know, not merely at what places rain fell, but also the amount of rain at each locality. Unfortunately, in most of the meteorological journals, the amount of rain is not stated at all; or the total amount of rain for the month is given, without stating the amount for each day. The following table indicates all the stations at which there is given for each day the amount of rain or melted snow:—

AMOUNT OF RAIN OR MELTED SNOW IN INCHES.

STATIONS.	Dec. 21.	Dec. 22.	Dec. 23.	Dec. 24.	Dec. 25.	Dec. 26.	Dec. 27.	Dec. 28.	Total of 8 days.
	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.
Reykiavig	...	...	...	...	...	...	0.45	0.42	0.87
St. Petersburg . .	0.06	0.01	...	...	...	...	...	...	0.07
Catherinenburg . .	...	0.01	0.01	0.01	0.06	0.01	...	...	0.10
Edinburgh . . .	...	0.32	...	...	...	...	0.31	...	0.63
Boston	...	...	...	...	...	...	...	...	0.78
Warsaw	0.01	0.11	0.61	0.02	0.06	0.02	0.28	0.13	1.24
Oxford	0.04	...	0.02*	...	...	...	...	...	...
London	...	...	0.10*	...	...	...	...	...	...
Brussels	...	...	0.22	0.03	...	0.28	0.02	0.05	0.60
Neisse	...	...	...	0.44	...	...	...	...	0.44
Prague	...	...	0.04	0.12	...	...	...	0.06	0.22
St. Bernard . . .	...	...	...	0.51	1.14	...	...	...	1.65
Padua	...	...	...	...	...	...	...	...	2.04
Orange	...	...	...	...	...	...	0.37	...	0.37
Florence	...	...	...	0.44	0.70	0.87	0.73	0.44	3.18
Marseilles . . .	...	...	...	0.08	...	...	0.09	...	0.17
Rome	...	...	...	0.02	0.71	0.36	0.30	0.24	1.63

* Snow not measured.

From the preceding data we should infer that the greatest amount of precipitation was in the northern part of Italy; but this conclusion is rendered somewhat doubtful by the evident unreliableness of some of the reports. At London, and also at Oxford, no rain is reported from the 23d of December to the end of the month, although this period embraced one of the most remarkable snow-storms ever experienced in England. During a violent snow-storm very little snow collects in an ordinary rain-gauge; and the observers at London and Oxford, and perhaps also at some other stations, appear to have taken no account of the moisture which was precipitated in the form of snow. The following particulars, collected from the columns of the *London Times* from December 27th to December 31st, will convey some idea of the violence of this storm in England:—

"At Brighton, early on the morning of Saturday, December 24th, there was a fall of snow, averaging a depth of six inches, and it continued falling at intervals throughout the day. About 5 P. M. it set in for a regular fall, which continued throughout the night. The snow fell incessantly all day Sunday, and continued without intermission till Monday night. The roads were rendered impassable, the snow being in some places five and six feet deep. On Sunday the mail-coach from Brighton to London had travelled about eight miles, when it fell into a drift of snow, and the coach could not be extricated. The guard proceeded with the mail-bags on horseback. At Lewes, after the storm, an immense avalanche of snow glided from the cliff hills, and entirely destroyed five houses, killing eight of the inmates.

"At Rochester the oldest inhabitants did not remember so heavy a fall of snow, which in some places was drifted at least forty feet.

"At Ipswich there was a light fall of snow on Friday night (December 23d), and in the morning the country was covered with it. A heavy fall of snow commenced about six o'clock on Monday, which in various situations drifted in ridges of one hundred feet wide by twelve and fourteen feet high.

"At Harwick the snow fell to ten and twelve feet in depth.

"At Hull the fall of hail and snow exceeded anything before witnessed for several years.

"At Newcastle the snow fell very heavy on Christmas day, and continued all night and Monday without intermission. The ground was covered in some places, even in town, twelve feet in depth.

"Between Wansford and Stamford, in the hollows of most of the roads, the depth of snow-drift was from twelve to twenty feet. In the high open roads there was no snow, it having been blown away by the wind.

"Between Leicester and Northampton, in some parts of the road, the snow had drifted to the depth of thirty, forty, and in some places fifty feet.

"In the neighborhood of Marlborough the drift had accumulated the snow in the hollows from twelve to sixteen feet in depth.

"Near Dorchester, where the snow had drifted, it was in some places five feet deep."

The editor of the *Times* remarks: "Never before within our recollection was the London mail stopped for a whole night at a few miles from London, and never before have we seen the intercourse between the southern shires of England and the metropolis interrupted for two whole days."

From the preceding statements it is extremely difficult to form any estimate of the *average* depth of the snow; but comparing the effects of this storm with those of the severest snow-storms in New England, we can scarcely estimate the amount of snow at less than two or three feet on a level; which, when melted, would furnish two or three inches of water. This would make the amount of moisture precipitated in the east of England about equal to that in the north of Italy.

Direction of the Wind.

The following table shows the direction of the wind at the several stations at noon of each day. The heavy-faced letters indicate strong winds. At about half of the stations the force of the wind was not particularly recorded:—

DIRECTION OF THE WIND.

STATIONS.	Dec. 21. Noon.	Dec. 22. Noon.	Dec. 23. Noon.	Dec. 24. Noon.	Dec. 25. Noon.	Dec. 26. Noon.	Dec. 27. Noon.	Dec. 28. Noon.
Reykiavig	N. E.	N. E.	N.	N. E.	N. E.	E.	E.	S.
Yarensk	S. W.	N. W.	N.	N.	N.	Calm	Calm	N.
St. Petersburg	S. W.	N. W.	N. W.	N. W.	N. W.	N. W.	S. W.	Calm
Christiania	...	N.	...	N.	N.	N.	N.	N.
Sandwick	S. W.	W.	N.	N. E.	E.	Calm	Calm	N.
Catherinenburg	**W.**	S. W.	S. E.	S.	S. E.	**W.**	W.	W.
Edinburgh	W.	W.	...	...	...	...	...	...
Moscow	S. W.	**S. W.**	N.	N.	W.	**N. W.**	Calm	Calm
Danzig	W.	N.	E. S. E.	E.	S. E.	**E.**	E.	E. S. E.
Stralsund	W. N. W.	N. W.	**E. S. E.**	**E.**	**E.**	**E.**	**E. S. E.**	E.
Altona	W.	W.	**N.**	**E.**	**N. E.**	N. E.	N. E.	E.
Dublin	W.	W.	N.	N.	N.	N. E.	N. E.	N. E.
Swislotsch	W.	N. W.	N. W.	N.	N. E.	N.	N.	N. E.
Bedford, Eng.	...	S. W.	N. W.	**N.**	**N. E.**	**E.**	N. E.	N.
Berlin	W.	N. W.	N. W.	N. E.	N. E.	N. E.	N. E.	E.
Harlem	W.	W. S. W.	N. N. W.	N. E.	E. N. E.	N. E.	N. E.	N. N. E.
Warsaw	W.	N. W.	S. W.	N. E.	**E.**	**E.**	**N. E.**	N. E.
Oxford	W.	S. W.	N.	**N. E.**	**N. E.**	**N. E.**	N. E.	N. E.
Koursk	Calm	S. E.	S. E.	S. W.	S. W.	S. E.	N. E.	N. E.
London	W.	W. S. W.	N.	**N.**	**N. E.**	**N. E.**	**N. E.**	N. E.
Cologne	...	S. W.	N. W.	N.	N.	N. E.	N. E.	N. E.
Brussels	S. W.	S. W.	N.	N. E.	N. E.	N. E.	N. E.	N. E.
Neisse	N. W.	N. W.	**S. W.**	**N. W.**	N. W.	N. W.	N. W.	N. W.
Prague	S. S. W.	N. W.	**W. S. W.**	**E.**	**E.**	E. N. E.	N.	N. N. W.
Cracow	N. W.	N. W.	**N. W.**	N. E.	**N. E.**	**N. E.**	N. E.	N. E.
Poltava	S. W.	Calm	S. W.	S. W.	E.	E.	N. E.	E.
Paris	W.	N. N. W.	N.	N. N. E.	N. N. E.	N. E.	E. N. E.	N.
Catherinoslov	S. W.	S. E.	Calm	S. E.	Calm	S. E.	S. E.	S. E.
Vienna	W. N. W.	W.	W.	N. E.	S. E.	E. S. E.	S.	E. N. E.
Munich	N. E.	S. W.	W. S. W.	N. E.	N. E.	W.	E.	Calm
Peissenburg	N.	W.	**W.**	**N. E.**	E.	E.	N. E.	N. E.
Buda	N. W.	N. W.	**W.**	N.	N.	**E.**	S.	N.
Zurich	...	N. N. W.	S. W.	N.	N. N. W.	N. N. W.	E.	N. W.
Geneva	...	N. E.	S. W.	...	S.	S.	S.	N.
St. Bernard	S. W.	N. E.	N. E.	S. W.	S. W.	N. E.	N. E.	S. W.
Milan	E.	W.	N. W.	E.	**S. E.**	S.	S. S. W.	S. W.
Padua	...	...	...	...	E.	W.	N.	...
Bologna	E.	W. N. W.	W.	**S. S. E.**	**E.**	**S. S. W.**	W.	W.
Orange	N.	N.	N.	...	N.	N.	N.	N.
Florence	N. E.	E.	E.	S.	S. E.	S. W.	W.	S. E.
Toulouse	N. W.	W. N. W.	W.	N. W.	**N. W.**	S. E.	N.	W. N. W.
Marseilles	N. W.	N. W.	**N. W.**	N. W.	**N. W.**	**N. W.**	N. E.	N. W.
Rome	N.	N.	N.	**S.**	**S.**	**S. W.**	S. W.	S. W.
Naples	E. N. E.	N. E.	S. S. W.	S. W.	S.	S. W.	W. S. W.	S. S. W.
Cadiz	E.	E.	N.	N.	N.	N.	N.	N.

On the eight accompanying charts arrows have been drawn, representing for each day the direction of the wind, according to the preceding table. It will be seen that on the 21st the wind blew from the west or southwest throughout nearly every part of Europe, except near its southern border. In Italy, and even as far north as Munich, the prevalent direction was from the northeast, and in Southern France it was from the northwest. These winds throughout the whole of Europe coincide remarkably with the average direction of the winds for the month of December. We find, then, on the 21st no considerable disturbing force operating upon the wind in any part of Europe. There was a storm, indeed, prevailing in Russia; but the amount of vapor precipitated appears to have been small, unless near the extreme northeastern border of Europe.

On the 22d, over Great Britain, the prevalent winds are from the west; but over most of France, Germany, and the northern part of Russia, the prevalent wind is from the northwest. In Southern Russia the winds are from some southerly quarter. Here we see the first operation of a great disturbing force, which on the next day became more decided, viz., a cold current pressing down from the north over Sweden and Germany. The storm in Russia is now becoming more decided, and its influence upon the direction of the winds is seen in the south of Russia.

On the 23d, over the whole of Western Europe, and also in Northern Russia, the prevalent winds are from the north; in South Germany they are from the west or southwest; while in Italy the directions are very various. Here we see the further progress of the cold current from the north, sweeping over the whole of Western Europe, from Iceland and the Orkneys over Great Britain, France, and Spain, joining probably the trade-winds, and thus continuing on to the equator. In the neighborhood of the Russian storm, the winds deviate more from their mean direction, and exhibit a tendency inward towards the area of least pressure.

On the 24th, throughout all the northwest quarter of Europe, as well as throughout most of Germany, the prevalent direction of the wind was from the northeast; in the southern part of France it was from the northwest; and in Italy it was from the south. Here we see a decided tendency in the winds of Western Europe to circulate around a centre, and also to crowd inwards towards that centre. This centre was near Mont Blanc, which was also near the point of least barometric pressure. Nearly all these winds in Western Europe were strong winds, and in many places their force amounted to a gale. In Eastern Europe there is also some indication of a tendency to circulate around the point of least pressure in Russia; but on account of the small number of observations, this remark would not be entitled to much consideration, were it not for its close analogy with the phenomena of Western Europe.

On the 25th, throughout a circle of about 750 miles radius, there is the same tendency to circulate around a centre near Mont Blanc, with a more decided crowding inward of the winds towards the area of least pressure; and in Eastern Europe there is an apparent tendency to circulate around the point of barometric minimum in Russia; but on account of the small number of the observations this tendency is very imperfectly exhibited. In Western Europe the winds were almost everywhere strong winds, amounting in many places to a severe gale.

On the 26th the direction of the winds in Western Europe was nearly the same as on the 25th, and near the parallel of 50 degrees easterly winds now prevail as far eastward as the Black Sea; but in Italy the winds are generally inclined to the southwest. We see the same tendency of the winds to crowd inward towards the area of least pressure, and also to circulate around the centre of this area; and these winds, especially over Great Britain, were generally strong and violent.

On the 27th, between the parallels of 49 and 55 degrees, east and northeast winds still prevail as far east as to Central Russia; but the winds are less violent than yesterday. There is still a tendency to circulate around a central point; but this centre appears to be somewhat east of Mont Blanc. In Italy the prevalent winds are from the west and southwest; while in Austria they are from the south.

On the 28th, between the parallels of 46 and 55 degrees, north and northeast winds prevail as far east as Russia, and there is still a marked tendency of the winds inward towards the point of barometric minimum, which point is now situated over Northern Italy.

Origin of the Storm.

This storm appears to have originated in Western Europe. On the 21st, throughout the whole of Europe, the winds everywhere blew nearly in their normal direction. It should be noticed, however, that in Iceland the barometer stood 0.69 inch above its mean height. On the 22d the barometer at Iceland stood 1.13 inch above its mean height; and along the northwest border of Europe the barometer was everywhere unusually high. This unusual pressure of the atmosphere caused the air to flow towards places where the pressure was less; that is, towards Central and Southern Europe. Here was the origin of the northerly wind, which was experienced in Norway and Germany on the 22d. This northerly wind was cold, and under its influence the thermometer sunk below its mean height. This cold northerly wind interfered with the progress of the westerly wind which prevailed over Great Britain, so that the west wind was forced upward and compelled to flow over the north wind. By being thus elevated, it was cooled and a portion of its vapor condensed; and this was probably the origin of the rain which fell in England and Scotland on the 22d.

On the 23d the barometer in Iceland stood 1.33 inch above its mean height, and the northerly current has now displaced the westerly one throughout the whole of Western Europe, viz., in Great Britain, Ireland, France, etc. The westerly wind which prevailed over Great Britain on the 22d is now lifted above the earth's surface, and exists simply as an upper current. Its vapor is condensed by the cold of elevation, and thus originated the rain which prevailed over France on the 23d.

On the 24th the barometer in Iceland still continued more than an inch above its mean height, and this dense atmospheric wave has made sensible progress eastward, so that now as far east as Sweden the barometer is much above its mean height. The pressure of the air towards Central and Southern Europe now becomes stronger than before, and the westerly wind from the Atlantic is everywhere lifted above the earth's surface, and prevails as an upper current, while its vapor is condensed by the cold of elevation. This northerly current brings with it a considerable reduction of temperature, and north of the parallel of 46° the moisture which is precipitated descends in the form of snow. The heat liberated in the condensation of this vapor, expands the upper stratum of air, causing it to rise above its usual elevation, and thus to flow off above, causing a diminished pressure at the earth's surface, so that near the centre of the storm the barometer stood about three-fourths of an inch below its mean height. This point of least pressure was situated nearly over the Alps of Switzerland. The low state of the barometer in Switzerland caused the air to press inward from every point of the compass. It was quite impossible that the air should advance in straight lines towards the point of least pressure; but there was a general circulation of the air around the central point, with a crowding of the air inward towards the centre. The air thus accumulated over the area of least pressure must have risen from the earth's surface, and thus lifted still higher the westerly wind which formed the upper current, causing an increased precipitation, and consequently diminished pressure at the centre of the storm. As the wind which pressed down from the north crosses parallels of latitude whose diurnal motion eastward is greater than its own, it has a relative motion to the westward, and thus on the northern border of the storm the north wind becomes a northeast wind. For a like reason, on the southern border of the storm, the southerly wind becomes a southwest wind. Thus, the rotation of the wind takes place in a direction contrary to the motion of the hands of a watch.

A portion of the air which flowed off above from the region of low barometer probably spread northward, and increased the pressure in the north of Europe, thus adding new energy to what was doubtless the primary cause of the storm.

On the 25th, throughout the whole of Western Europe, the phenomena were nearly the same as on the 24th; but near the centre of the storm the barometer had fallen still lower, the depression now amounting to about one inch below the mean. On the north of Europe the high barometer still continues, and the line of one-half inch pressure above the mean has advanced steadily to the southward since the first commencement of the storm; so that while in North Italy the barometer is one inch *below* the mean, at Christiania, in Norway, it is four-fifths of an inch *above* the mean.

On the 26th, throughout Western Europe, the phenomena are nearly the same as yesterday; but the action of the wind appears to be less uniform, so that while in some places the rain and snow are more violent than yesterday, at other places they have ceased entirely.

On the 27th the phenomena continue quite similar to those of the 26th; but there is a general diminution in the violence of the storm, and the greatest depression of the barometer scarcely amounts to two-thirds of an inch. This diminution of violence is probably due to the general prevalence of the cold current from the north, and the diminution of the westerly wind from the ocean, which furnished most of the vapor of precipitation.

On the 28th we find the same causes operating with an energy still further impaired, and probably from the action of the same cause, viz., the failure of the upper current, which furnished the vapor of precipitation. After the 28th the operation of the same causes grew gradually feebler, until at length they disappeared entirely.

Comparison of the Lines of Barometric and Thermometric Oscillation.

It is very obvious from an inspection of the charts that the lines representing the fluctuations of the barometer are very unlike those which represent the fluctuations of the thermometer, and it is not easy to discover any connection between them. In the United States, while the barometer falls during a storm of rain or snow, it is common for the thermometer to rise, so that the area of low barometer corresponds nearly to that of high thermometer, and the lines of equal barometric disturbance bear a considerable resemblance to the lines of equal thermometric disturbance. But in the storm of December 25th, throughout nearly all of Western Europe, the thermometer was pretty uniformly depressed about ten degrees below its mean height; yet the barometer in Christiania stood four-fifths of an inch *above* its mean height, while in North Italy it was about one inch *below* its mean height. Hence, we infer that change of temperature (as shown at the earth's surface) is not one of the principal causes of the fluctuations of the barometer. While in North Italy the barometer sunk an inch below the mean, the thermometer at the earth's surface scarcely anywhere rose as much as five degrees above the mean. Yet heat is always liberated when vapor is condensed, and we must hence infer that this condensation took place at a considerable elevation above the earth's surface—at an elevation greater than that of St. Bernard, which is more than 8,000 feet above the sea; for at St. Bernard there was a great fall of snow, but no rise of the thermometer.

It is also evident that the cause which produced the fall of the barometer in Switzerland, operated at an elevation of more than 8,000 feet above the sea, for at St. Bernard the oscillation of the barometer was as great as it was at the level of the sea.

On the 21st of December, in Russia, the area over which the thermometer was ten degrees above the mean corresponded tolerably well with the area of snow and rain, but was a little displaced, overlapping on the southeast side, and falling short on the northwest side. A similar remark is applicable to December 22d.

On the 23d, throughout the whole of Europe, the area over which the thermometer stood above its mean height exhibited nearly the same form as the area of rain and snow, but was displaced towards the south, overlapping on the south side and falling short on the north side. A similar remark is applicable to the 24th, at least as far as respects the Russian part of the storm.

The following is my explanation of these facts: In a great storm of rain and snow, when vapor is condensed, heat is liberated, which raises the temperature of the surrounding air above its mean height. This heated air is frequently wafted off by an upper current, and the heat of the upper stratum is partially communicated to the lower stratum, so that the area of high thermometer no longer corresponds with the area of rain and snow. The displacement of the one surface, as compared with the other, indicates the direction of this controlling upper current. From the 21st to the 24th of December, 1836, this upper current in Europe appears to have been from the northwest.

The fall of the Barometer in Great Storms is not the effect of Centrifugal Force.

Some persons have imagined the fall of the barometer in a storm to be due to centrifugal force. They say "the atmosphere constituting the body of the storm is driven outward from the centre towards the margin, just as water in a pail which is made to revolve rapidly flies from the centre and swells up the sides." But according to the principles of mechanics, the centrifugal force of a body revolving in a circle is to its weight as V^2 to 32 R, where V represents the velocity in feet per second, and R is the radius of the circle expressed in feet. Now, on the 25th of December the barometer fell half an inch below its mean height throughout a circle whose radius was 400 miles. We will estimate the velocity of the wind at 70 miles per hour, or 100 feet per second. Then

$$C : W :: 10000 : 32 \times 400 \times 5280$$

$$\text{or } C : W :: 1 : 6758;$$

that is, the centrifugal force is less than $\frac{1}{6000}$ part of the weight of the revolving body—a force which would depress the barometer less than $\frac{1}{200}$ of an inch, whereas the barometer actually fell a half inch below its mean height; in other words, the centrifugal force generated by the rotation of the wind had no appreciable influence on the state of the barometer.

Supposed connection between the American and European Storms.

The European storm of December 25, 1836, was entirely independent of the American storm of December 20th. The rate of progress of the American storm of December 20th was such that it could not have reached England before the 27th; whereas the European storm had become fully organized on the 23d, and the first movement of the storm can be distinctly traced in Germany on the 22d. The European storm evidently originated in Europe; and the American storm gradually wasted away, and probably could not be traced beyond the middle of the Atlantic.

Generalizations.

By comparing the European storm of December 25, 1836, with the American storm of December 20, 1836, and also the storms of February 4 and 16, 1842, of which I have published an investigation in the *Transactions of the American Philosophical Society*, vol. ix. pp. 161–184, we are led to the following generalizations. Some of these conclusions are substantially the same as given by Mr. Espy, in his Fourth Meteorological Report; but several of Mr. Espy's conclusions are only true when applied to American storms.

1. The area covered by a violent storm of rain or snow is sometimes nearly circular in form; sometimes its form is very much elongated or elliptical, its length being two or three times its breadth; and frequently its form is very irregular. In

the winter storms of the United States, the north and south diameter is generally very much greater than the east and west diameter.

2. When storms are circular in form, the area of rain or snow is sometimes 1,500 miles in diameter; when their form is elliptical, the area of rain or snow is sometimes 1,000 miles wide, and 2,000 or 3,000 miles long.

3. Violent storms sometimes remain sensibly stationary for four or five days; but generally the centre of a storm has a progressive movement along the earth's surface. The rate of this progress has been observed to vary from zero to 44 miles per hour. From our limited number of observations, it seems probable that American storms travel more rapidly than European storms.

4. Within the limits of prevalent westerly winds, when violent storms advance with considerable rapidity, the direction of progress is always from west to east. This direction is not absolutely uniform, but has been observed to vary from about due east to N. 54° E.

5. Great storms of rain and snow are accompanied by a depression of the barometer near the centre of the storm, and a rise of the barometer near the margin; but this rise is not generally uniform along the entire margin.

6. The depression of the barometer at the centre of a storm sometimes amounts to more than an inch *below* the mean height; and the rise along some portion of the margin sometimes amounts to more than an inch *above* the mean height.

7. Winter storms commence gradually, and generally attain their greatest violence only after a lapse of several days; after a time their violence gradually diminishes, and at length they disappear entirely. This succession of changes requires a period of several days, sometimes one or two weeks, and possibly even longer. Sometimes all these changes are experienced over the same country; that is, the storm makes no progress from place to place. More commonly, however, the storm travels along the earth's surface; and although the same storm may continue for one or two weeks, or even longer, its duration at any one place may not exceed one or two days.

8. For several hundred miles on each side of the centre of a violent storm, the wind inclines inwards towards the area of least pressure, and at the same time circulates around the centre in a direction contrary to the motion of the hands of a watch.

9. In Europe, as well as in the United States, on the north side of a great storm the prevalent winds are from the northeast, while on the south side they are from the southwest.

10. The force of the wind is proportional to the magnitude and suddenness of the depression of the barometer; but very near the centre of a violent storm there is often a calm.

11. On the borders of the storm, near the line of maximum pressure, the wind has but little force, and tends outwards from the line of greatest pressure.

12. The wind uniformly tends from an area of high barometer towards an area of low barometer; and this is probably the most important law regulating the movement of the wind.

13. In a great storm, the centre of the area of high thermometer frequently does

not coincide with that of the area of low barometer, or with the centre of the area of rain and snow. In the United States, on the northeast side of a storm, at a distance of over 500 miles from the area of rain and snow, the thermometer sometimes rises even twenty degrees above its mean height.

14. The storms of Europe are very much modified, and sometimes in a great measure controlled by the Alps of Switzerland. By the interposition of these mountains the air which sweeps over them is forced up to a great height, where it is suddenly cooled; its vapor is condensed; heat is accordingly liberated, by which the surrounding air is expanded, and rises above the usual limit of the atmosphere. It thence flows off laterally, leaving a diminished pressure beneath the cloud; that is, the barometer shows a diminished pressure in the neighborhood of the mountain. The mountain thus becomes the centre of a great storm, and the storm may continue stationary for several days, being apparently held in its place by the action of the mountain.